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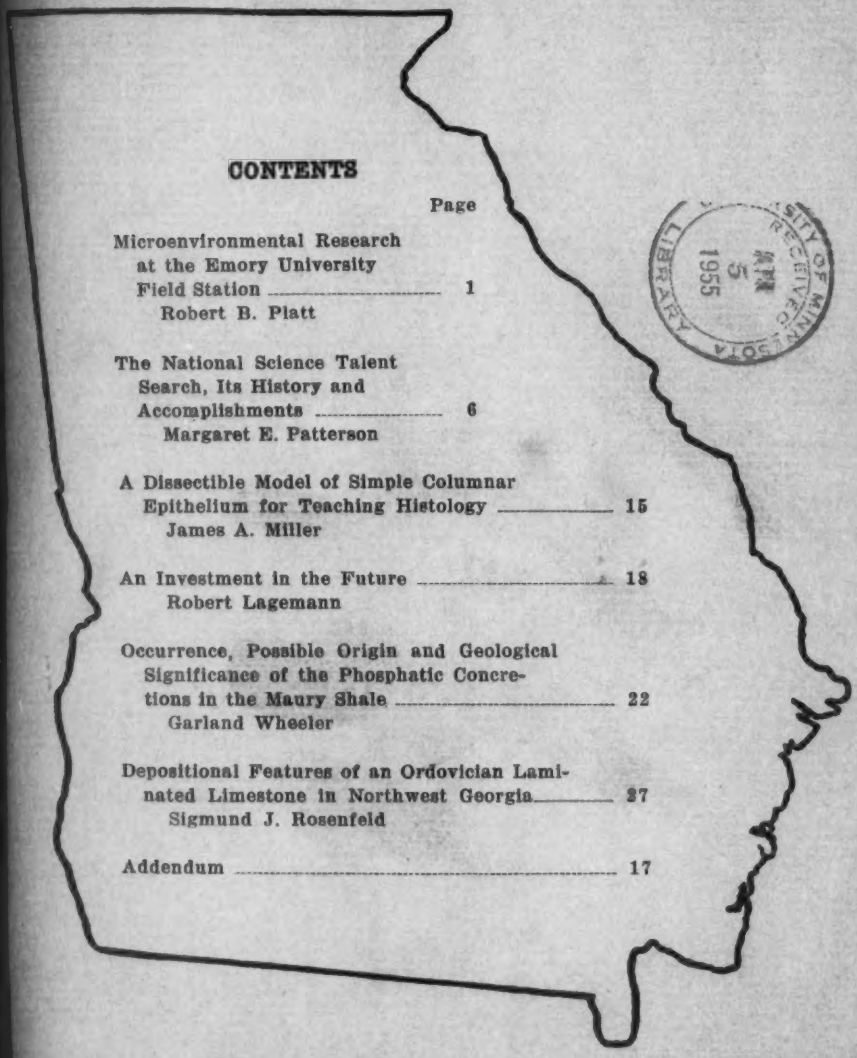

CONTENTS

Page

Microenvironmental Research at the Emory University Field Station 1
Robert B. Platt

The National Science Talent Search, Its History and Accomplishments 6
Margaret E. Patterson

A Dissectible Model of Simple Columnar Epithelium for Teaching Histology 15
James A. Miller

An Investment in the Future 18
Robert Lagemann

Occurrence, Possible Origin and Geological Significance of the Phosphatic Concretions in the Maury Shale 22
Garland Wheeler

Depositional Features of an Ordovician Laminated Limestone in Northwest Georgia 27
Sigmund J. Rosenfeld

Addendum 17

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THE BULLETIN of the GEORGIA ACADEMY OF SCIENCE is published four times each year, in January, April, June, and September and is sent without charge to all members of the Academy.

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MICROENVIRONMENTAL RESEARCH AT THE EMORY UNIVERSITY FIELD STATION

ROBERT B. PLATT
Emory University

A program of microenvironmental research at the Emory University Field Station was conceived and initial planning begun in 1951. Actual experimental work was started in May, 1952. The term microenvironment refers to the environment within relatively small spatial limitations, as for example a woodland, or a rotting log within the woodland. The primary objective of this program was the development of an experimental laboratory in the field, with a design sufficiently basic and flexible to permit its use for a variety of microenvironmental problems, concerning both plants and animals.

Urgent need for the type of research described here has been clearly established by recent publications emanating from both applied and pure fields of biological research. The uniqueness of this particular program stems from its emphasis upon a total analysis of the environment with reference to specific organisms rather than an emphasis upon limited factor analyses. This necessitates precise and continuous measurement of the major environmental factors through several years vertically from subsurface to above tree crown zones, and horizontally through various community types from points of greatest to points of low or zero population densities.

From the standpoint of the organism under consideration, not only must comparable distributional data in space and time be collected and evaluated, but also laboratory studies must be initiated to determine its limit of tolerance to various environmental factors for each stage in the life cycle. With these kinds of data in hand there is a reasonable expectation that the critical conditions or combinations of conditions operating to control the population of the organism may be determined. Correlative objectives are to demonstrate the feasibility of this total type of approach to an understanding of organisms, and to develop instruments, techniques and methods requisite to it.

Information gained from such investigations have broad biological implications, including those of Public Health importance. Many investigations on the natural history of disease have involved studies of specific environmental factors which influenced the behavior of various organisms involved in maintenance of parasite systems. For example, in the arthropod borne viral encephalitides, man and other higher mammals are infected incidentally and represent blind paths in perpetuation of these infections. The normal cycles of transmission involve passage of virus among various birds by suitable arthropods. Although laboratory studies have shown that a wide spectrum of wild birds and mosquitoes are susceptible to infections with encephalitis virus, and that they serve as adequate laboratory reservoirs of

vectors, extensive field studies are necessary to determine whether or not these species are involved in perpetuation of infections in nature.

In delineating these relationships, the critical factors are those which characterize the microhabitats sought coincidentally by vectors and susceptible hosts. Preliminary studies on the Field Station project have demonstrated that a definite stratification of mosquito species does occur, and that the species represented at any one

FIG. 1. *View of the insectary and two of the laboratories at the Emory University Field Station. Structures not shown include two other laboratory buildings, an office building, shop and garage.*

location at a particular time is determined to a large extent by climatic conditions. Further elucidation of causal relationships will advance knowledge of animal associations involved in perpetuation of encephalitis.

As a first step in translating the basic concepts of this program to reality, the Emory University Field Station was chosen as the most appropriate site for these reasons:

1. The Station is jointly operated by the Ecology Section of the Communicable Disease Center of the U. S. Public Health Service. A year round staff is maintained of 12 to 15 people who are interested in various phases of public health ecology. This program has many interests in common with that organization and the work has been integrated where feasible.

2. The Station is located in the upper Gulf Coastal Plain, adjacent to the transition zones between the Lower Appalachian and the Piedmont provinces. Thus, in addition to the 15 distinct habitat types which have been defined for the region immediately adjacent to the Station, these other physiographic regions are available for further comparative studies.

3. The area is unique for the amount of environment data accumulated by the Field Station during its 13 years of existence. Extensive data on the hydrology, physiography, and climatology

of the region, including a series of specially prepared maps and aerial photographs, made possible the initiation of such a program at a much higher level than would otherwise have been possible.

4. The Station was already equipped with specialized laboratories, as for example, air conditioned animal rooms, a photographic darkroom, a good library, reference collections of plants and animals, constant temperature baths and cabinets, etc.

5. The good will of the people in the area, coupled with a sparse population, have served to provide almost total protection for field installations, located even as far as 20 to 30 miles from the station. Thus the safety of expensive equipment and the continuity of observations was assured.

The second step was the selection of a particular experimental site

FIG. 2. *View of the 50 foot tower in an oak hammock. The platforms greatly facilitate the determination of vertical environmental gradients as well as vertical distribution of selected organisms.*

within this region for intensive study. The Mossy Pond area was chosen because:

(1) There is an unusual diversity of habitat types and ecotones, which in themselves represent environmental extremes.

(2) The Station has permanent control of about 15 acres of surrounding land.

(3) This particular area has been studied extensively for the preceding 13 years.

(4) It and the surrounding country is in as natural a condition as any observed in this part of the coastal plain.

As a third step, the Mossy Pond area has been developed into a field laboratory, as follows:

1. Several permanent stations have been established. Most of the work, however, is being concentrated at two of them, which represent ecological extremes, one being a dense oak hammock at the edge of a solution pond, and the other an adjacent old field. In order to make observations along vertical as well as horizontal gradients, sub-stations were established at each of the above two habitats at levels which correspond to vegetation layers: ground surface (leaf litter), one foot (herb layer), three feet (low shrub), six feet (tall shrub), 15 feet (low tree crown), 25 feet (tree crown), and 50 feet, in the hammock only (above tree crown level). Two wooden towers, each 50 feet tall, have been erected in the woods and in the open field to facilitate work at each of these levels. The open field tower, completed in January of 1955, replaced a defoliated tree which had been used up to that time. Provisions were made for the establishment of additional sub-stations as circumstances may dictate.

2. Electric power lines were brought into the area, so as to permit the use of electrically operated collecting, indicating and recording devices.

3. Some three quarters of a million I.B.M. cards had been punched from data previously collected, and provisions were made for the extension of this type of service for the new data obtained. In addition, two separate Keystone punch cards for the recording of other types of data have been developed.

4. Factors selected for intensive study are soil and air temperature, soil and air moisture, heat balance, intensity and wavelength of light, water tables and pond levels, rainfall, wind and wind direction, and barometric pressure.

5. Indicating and recording instruments for these environmental factors have been selected and installed. These had to be sensitive enough to detect small differences in horizontal and vertical gradients of environmental factors and also be rugged enough for continuous field use. For the especially difficult factor of atmospheric moisture, lithium chloride-type indicators were installed in the winter of 1955 at each level of the two primary stations, and are connected to multiple point recorders, which also record temperatures on the same chart.

6. Automatic collecting devices especially designed for arthropod disease vectors, have been installed at each level, one being a system

of electrically-timed light traps, and the other non-attractant-type electrically-operated sweep nets.

7. The development of laboratory facilities and instrumentation has been concomitant with that of the field installations.

An indication of the experimental work already accomplished may be in order. A two-year ecological life history study of Spanish Moss has been completed as a doctoral dissertation. A two-year continuous study has been completed on the distribution and abundance of some 37 species of mosquitoes by the use of light traps, and an additional 7 months study using mechanical sweep nets. A definite study has

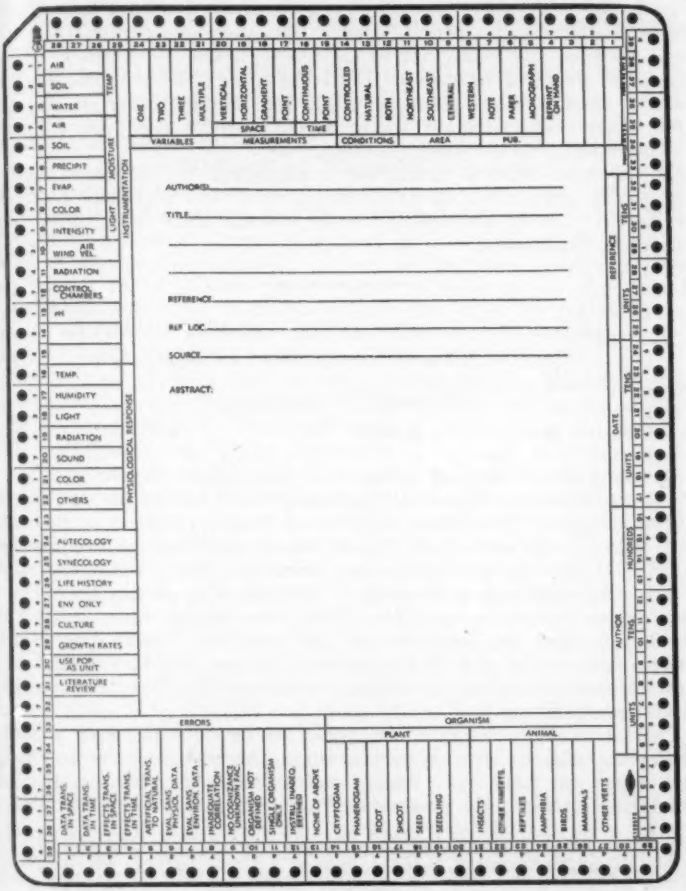

FIG. 3. *One of two 8" x 10" Keysort punch cards developed for bibliographic use.*

been completed on the responses of Anopheles mosquitoes to controlled conditions of light, temperature, and humidity. Hourly determinations for three 24 hour periods for all of these factors have been carried out and two years of continuous data on certain of these factors are now available. Data have also been obtained on evaporativity gradients along five sets of vertical stations. Other special projects have included the development of a multiple factor environmental gradient control chamber, and a project on the use of color temperature as a standard for light response studies in animals.

The planning and execution of this program represents the combined efforts of many people, to all of whom I gladly acknowledge my indebtedness. I sincerely regret that each one cannot be named here. This is, and could not be otherwise, a teamwork project. I am especially grateful to Melvin H. Goodwin, Jr., Director of the Field Station since its inception in 1941, for freely giving of his time and wisdom, and without whose active support the program could not have achieved its present status.

In addition to that previously mentioned, the program has received the support of a grant-in-aid from the National Institutes of Health. Use of these facilities by investigators from other institutions is encouraged.

THE NATIONAL SCIENCE TALENT SEARCH
ITS HISTORY AND ACCOMPLISHMENTS

MARGARET E. PATTERSON
*Science Service**

Four persons[1] lunching together in New York City in the fall of 1941, conceived the idea that has come to be known as the Science Talent Search. The express purpose of their meeting was to decide how a fund, available from the Westinghouse Electric Corporation, could best be spent to aid young scientists. They sought a means of selecting students with unusual aptitude for science as early in their school careers as possible. The structure for such a program, decided on that day, is basically the same today when the Science Talent Search for the Westinghouse Science Scholarships is only hours from its deadline (midnight, December 27, 1954) for the 14th annual competition.

The fortunate set of circumstances that brought the four together on that day has resulted in a long range program of a size and scope that could not have been anticipated on that leisurely noon when Pearl Harbor was only weeks away and a shortage of scientific and

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*Read at The Academy Conference, December 27, 1954 by Margaret E. Patterson, Executive Secretary, Science Clubs of America, Science Service, Washington, D. C.

1. Mr. G. Edward Pendray of Westinghouse; Dr. Harlow Shapley; Mr. Watson Davis; Miss Margaret E. Patterson.

engineering manpower, not then recognized by the general public, was to mount to proportions of national and international concern.

Since that time Westinghouse, through its Educational Foundation, has poured three quarters of a million dollars into this experiment. That Company considers this contribution to basic scientific research as important as any like sum spent in the same time period.

The time and effort supplied to the project by its other partner, Science Clubs of America, administered by Science Service, in conducting the Search since its inception, has been well spent in one of the most gratifying of its efforts to popularize science and bring it close to the public through the press and other channels of communications. The success of the Search has inspired the establishment of the National Science Fair for still younger students.

In the past 13 years 167,910 high school seniors have faced the challenge of the Science Talent Search's hard, three-hour, Science Aptitude Examination and 34,976 of them have toughened their mental fiber by completing all of the requirements of the competition. A total of $143,000 in Westinghouse Scholarships has been provided among 520 winners. It is estimated that about $4,000,000 in additional scholarships and financial aid has come to the 3,900 winners and honorable mentions as a direct result of their Search status. A less tangible, though perhaps as important value, has been the respect for scholastic achievement engendered by the Search. It has become socially desirable among the 'teen age population to become a scientist and the awe accorded those who achieve it is similar to that formerly reserved for the sports hero.

To faculties of secondary schools, throughout continental U.S.A., the competition has become a device for rallying the latent abilities of brilliant students, prone to slide along in curricula too easy for their brainpower and hence conducive to laziness and lack of enthusiasm. Teachers agree that the Search has sharpened their own comprehension of the requirements of scientific research and has helped them to recognize those students capable of coping with it.

Colleges, universities, and technical schools quickly grasped this means of spotting above-average science students and from the first they have used it as a way of dispensing scholarships and other financial aid to students on whom they can rely for exceptional achievement. Their growing faith in the selection methods is evidenced by the offers they make to the 300 seniors honored each year. It is not unusual now for some winners to receive scholarship bids totaling $30,000 to $50,000 and many of the 260 honorable mentions annually report offers only slightly less "staggering."

Academies of Science and other professional groups have watched the program's development with a friendly eye from the beginning. Since 1946, when Virginia and Tennessee took the lead, a growing number of them has taken an active part in the extension of the idea. In 1955 a total of 26 states and the District of Columbia will hold their own State Science Talent Searches by agreement with Science Clubs of America and will award scholarships or other assistance within their own states to students who competed in the

National Search. In some cases the funds dispersed through State Searches exceed the $11,000 in scholarships offered in the National competition. For example: In 1954 Indiana reports that 94 students, honored in their state search, divided more than $50,000 in scholarship aid.

Other industries, and scientific and philanthropic agencies, following the leadership of the Search, have set up their own scholarship programs to widen the opportunity for secondary school scientists-to-be.

India, Pakistan, Scotland, England and Venezuela have taken preliminary steps to institute a search-type program in their countries. Inquiries on how the operation is carried on here also have come from other areas around the globe.

These direct and side benefits. to name only a few, are a high compliment to the effectiveness of the Search and serve to verify an original purpose: to provide a pilot plant guide to finding, counseling and conserving our most precious resource—human talent.

HOW THE SEARCH IS CONDUCTED

The basic pattern for the conduct of the Search has not varied in the main from that set up in the first year, but refinements in the technique are constantly in process as experience dictates changes that will improve the program. The 520 winners have been most useful in helping us to perfect the operation so that it has maximum appeal and effectiveness for the 'teen age scientist.

The program operates in this fashion:

Each spring all secondary schools in continental U.S.A. are alerted to the competition with a poster that urges the coming crop of seniors to concentrate during the summer on the study, research and experimentation they will report in the fall.

Early in the new school season another mailing to the same public, private and parochial schools gives full details, and offers the opportunity to the school faculty to request the proper number (approximately the top 20% of the graduating class) of examination materials.

In the 1953-54 school year examinations were sent for 16,344 seniors and 2,409 completed entries were returned. Girls accounted for 20% of the returns. It has always been a policy of the Search to encourage the participation of girls in science. The awards are prorated on the basis of the number of girls who enter.

Each complete entry consists of:

1. A Science Aptitude Examination, administered to the student under strict proctoring. This is especially prepared for the Search by Drs. Harold A. Edgerton and Steuart H. Britt, who have been responsible for the design and construction of the test each year since its beginning.
2. A Personal Data Blank which contains the faculty's opinion of the contestant and a record of his scholastic achievements.
3. A report of about 1,000 words on "My Scientific Project" prepared by the student.

After the deadline no entries are considered for judging. Only complete entries are judged.

After all examinations are scored a cutting score is determined that reduces the number to about one-half. In 1953-54 the total points possible were 138. The score range was 20 to 118 for boys; 20 to 102 for girls. A score of 78 for boys and 63 for girls was required to be considered for national honors.

Contestants surviving the first hurdle are eligible for the next—the faculty recommendations. The third hurdle consists of evaluation of scholastic records. By the time the Reports are considered the number of contestants remaining in the running has been reduced to 350-400. Report readers, representing the various sciences, read and independently score the reports. Papers too far out of the field of any of the readers are submitted to experts in that field for comment. In group discussion at intervals the readers arrive at group judgment.

Drs. Edgerton and Britt along with a third judge, Dr. Rex Burton, then weigh all the evidence to determine the selection of the 300 to receive honors. Of these, 260 receive honorable mention and 40, named as winners, are invited to Washington, D. C., for the all-expenses-paid five-day Science Talent Institute in late February or early March. At that time they compete for the Westinghouse Science Scholarships.

Each of the 300 has the privilege of requesting that letters of recommendation be sent to any accredited institution of higher learning he considers attending. A total of about 1,000 letters of this kind are sent out each year.

All colleges, universities and technical schools receive lists of the 300 and also are informed of the State Science Talent Searches. They also receive a list of the Directors of these to whom they may write for the lists of students selected for honors in the 27 states.

The 40 who attend the Institute are interviewed individually and in groups by the judges before the decision is made as to the size of scholarship to be awarded. The $11,000 is generally given as 30 $100 scholarships; 8 of $400; one of $2,000 and the top Westinghouse Grand Science Scholarship of $2,800. The judges are at liberty to vary the size and distribution of awards to a certain extent. Monies are paid directly to the student upon enrollment in college to be used as desired in furthering his education. Larger scholarships are given in installments on completion of satisfactory semesters after the first payment. While alternates are named they are seldom able to move into a higher bracket.

The scholarships are given for merit in science. Financial need is not considered. However, great care is taken to be sure those who need it get financial aid elsewhere.

The 40 live at the Hotel Statler during their stay at the Institute. They take trips to points of scientific interest, visit research laboratories, and hear lectures by eminent scientists invited for the Institute. They have many occasions when they may talk over their plans and projects with specialists in their field. An attempt is made to

present to them a broad view of what problems lie ahead in scientific research and a close inspection of what scientists are like and the conditions under which they work.

The 40 are required to come without adult escort as a test of their independence and maturity. This throws the group on their own resources with the result that they become a closely knit group during the five days. Every poll has indicated agreement that meeting and mingling with 39 others of their own—or better—mental capacity is the No. 1 gain of the whole trip. The No. 2 highlight is the opportunity to meet adult scientists.

The winners are warned that they, as "symbols" will be in the limelight for a period of time. Their youthful enthusiasm and ability, closely covered by the press, radio and TV, do more to dramatize to the public the whole concern of finding and recognizing science talent than any other method we have been able to devise.

ACHIEVEMENTS OF SCIENCE TALENT SEARCH WINNERS

The first Search culminated in record breaking time. About nine months from the day the idea was agreed upon, we sat, the night before their arrival, wondering aloud what manner of people these First Forty would be. Our fears as to whether we would enjoy them and they us evaporated as soon as they stepped off the trains that had brought them from all parts of the country. They were—and this is true of all consecutive 40s—the most thoroughly likeable individuals that could be desired and a comradeship grew among them almost spontaneously. Adolescents are perhaps the most adaptable creatures but that particular breed with science as their major interest are especially fascinating. The same open-mindedness that is characteristic of their approach to science extends to all other facets of their personality. So, it is no wonder that all of us concerned look forward each year to greeting the new 40 with an anticipation that comes from the stimulating atmosphere they create. We call it "our spring tonic" because it comes in late February or early March now. But that first Institute was held in July and it was hot as only Washington can be hot. That occasioned the first change in pattern. The whole program was set so that the temperature would be more favorable, so it would coincide more correctly with the school year and in order to give the students a maximum opportunity to avail themselves of other scholarships generally awarded in mid spring.

When the first 40 returned home they insisted that the camaraderie of their time together be continued by correspondence. At first this was by an abstracting of their voluminous and delightful letters into a "round robin" letter that was circulated to each. But new 40s came along and the editorial board jumped accordingly and soon I found myself with a full size publication on my hands. We gave it a name—The Science Talent Searchlight—and the last one issued had 76 pages of tightly packed information gleaned from the letters of hundreds of contributing winners, who through this journal are able to keep up with their own 40 as well as get acquainted with all those that came before or after them.

The Searchlight serves its original purpose of keeping the winners together but it has become, too, a means of compiling data about them that enables us to understand how a scientist grows. It provides the statistics on their development as a group.

Most of the following information is taken from Searchlights prepared for the past 13 years.

Because they are through or almost through with their formal education let's look at the 240 winners that were chosen from 1942 to 1947:

There are 63 women and 177 men in the group.

They are 23 to 31 years of age.

Ninety-three per cent[2] of them are science trained. Bachelors degrees are held by 95% of them; masters degrees have been granted to 70% and 48% have already earned a doctor's degree. Dr. Wolfle, in his new book "America's Resources of Specialized Talent," states that in 1950 2.03% of those who received bachelor's could be expected to take doctors degrees. By this figure these 240 are 24.5 times the national average.

The high quality of their scholarship and wide range of their interests are shown by the large number who hold membership in Phi Beta Kappa, Tau Beta Pi, and Sigma Xi as well as dozens of other honorary, professional, and social organizations.

Physical sciences lead in their choice of careers with physics and mathematics outdistancing chemistry. Engineering has attracted another large group. Of those who have chosen biological careers the largest number is in medicine. Almost every other science is covered by at least one winner. Non-science choices have been English, languages, law, religion, and political science, though even here the science persists, as for instance, a language major does science translating; a lawyer is also an aeronautical engineer.

The largest number of the 240 have taken positions in industry where most do research, though a few are in sales and executive assignments. Those in government occupations are wholly in research or in the military as a career. Academic positions are at the college-university level, with major emphasis on research. Those in medicine are mainly doing research, though a few have private practices. At the time the oldest was 28 the reported highest salary for men was $8,820; for women, $4,800.

Publications[3] in the scientific and technical journals give proof of the research abilty and accomplishments of this group. It is expected that the number will increase in the future.

The women tend to marry scientists and engineers. They continue to work until there are children and then devote full time to that and assist their husbands in their professional assignments or hold

2. In the group one is deceased; one could not attend college for health reasons; and the rest chose careers other than science or their college achievements are not known.

3. Since the Search has attempted to find potential research scientists there is probably no better indication of its success than the list of their publications prepared for an issue of the Science Talent Searchlight.

part time jobs. A few mothers in this group have as many as three children.

The men do not so frequently marry scientists but like the women choose mates with college training. The largest number of children reported by a father in this group is five.

Two couples who met through the Search are now married. All four have doctors degrees.

It appears that later years of Search winners will exceed the scholastic achievements recorded for these 240. It would be pleasant to think that this indicates better selection, and this may be true, but it is only fair to cite that the 1942-47 group was most affected by military service and wartime disarrangement of plans.

The Searchlight serves as a source of considerable guidance for younger winners who may profit by the know-how accumulated by their predecessors.

To summarize a few examples taken from a recent issue:

1. How do you get a summer, part-time and full-time job? The details of these intricacies are accompanied by advice on how to keep the job or utilize it as a recommendation for the next.

2. Is it better to accept a job in industry? government? the academic? Answers to this are complete with the advantages and disadvantages of each type employment cited by those who have experienced it.

3. Should one specialize early or diversify the college curriculum? The opinion:

> 81 votes—Diversify your curriculum.
> 22 votes—Specialize early.
> 23 votes—Do both by specializing in class and adding the "culture" on the side by wide reading, attending lectures, concerts, mingling with people in other fields, etc.

4. Is it better to train as a specialist in one field or prepare for a career in a split field such as biochemistry, chemical physics, mathematical bio-physics? The opinion:

> Be a specialist in one field if you can't be satisfied any other way but "barrier breaking" is the new way of science and highly favored by elder winners. Keep your vision broad, not pigeon holed. Attempt to train yourself to cross from one field to another or keep fluid enough to be prepared to change vocations. As to how to do this they recommend younger winners:
>
> a. Acquire a good solid background in the basic sciences including math.
> b: Become an authority, or at least have superior working knowledge and ability, in one field.
> c. Learn thoroughly the methods common to all sciences.
> d. Learn to work well with other people.
> e. Keep your mind open to new ideas in your science, in other sciences and in all fields by reading, attending

lectures, special courses, learning to use new "tools." belonging to groups and widening your circle of friends and acquaintances.

5. What constitutes success in science? The opinion:
   93 votes—Advancement of science.
   30 votes—Contributing to human welfare.
   18 votes—Happiness and personal satisfaction.
   14 votes—Achieving one's goal.
   3 votes—Money and position.
   25 votes—Miscellaneous (not categorized in above).

Youthful winners, alarmed that they cannot make up their minds about choosing a career, are put at ease when they find that this is not at all unusual among scientists. A poll of older winners shows that only about one-fourth actually become what they predict they will be when they are high school seniors. This, they say, is due to the lack of comprehension of the scope of science at that time and to one's own development as training progresses.

Summer jobs are regarded as almost a must by Search winners regardless of their financial status. This opportunity to sample different employment during their college vacations makes it easier to choose the ideal position when schooling is over. They seek jobs in laboratories mainly, though some prefer outside work that is a change from confinement of college classwork. Some want straight manual labor to give their brains a rest and their muscles a tune-up. One, for instance, laid tombstone foundations for summer employment. The opportunity for vacation employment as a direct result of having won in the Search has been growing in the past few years. The National Bureau of Standards has sought and employed the winners during their first summer out of high school for a number of years and has been so well satisfied with their capacity for filling significant jobs that they have issued a blanket invitation to all winners to work there if they are within the fields covered in that research establishment. The growing number who have started here and return for several summers has built up a summer colony of winners in Washington that serves as a social club which in itself is a most valuable benefit of the vacation experience. A similar program started two years ago by Westinghouse at Pittsburgh warrants a contemplated expansion and serves aspiring engineers, physicists and mathematicians especially well. Housing accommodations there have been arranged at Carnegie Institute of Technology so the 'teen-agers have group campus life along with their industry experience. The Oak Ridge National Laboratory is making an offer to winners for the coming summer if they fit the requirements of age, citizenship and science field. This early acquaintance with actual work in laboratories is invaluable to the winners and they have attempted to insure these benefits for their successors by pooling their experience to pass along to new winners. The 40 chosen for 1955 will receive a bulletin prepared by previous winners, telling them how to make the transition from lofty high school senior to job holder on a low rung of the research laboratory ladder.

Winners engage in hobbies to a degree that is above average. In a check of these the most popular areas were: sports and athletics, subject matter hobbies, photography, music, mechanics, arts and crafts and collecting in that order. However, there was a range that covered almost every conceivable one right down to sleeping late and playing practical jokes.

The progression of interest according to age shows that Search winners have learned early the relaxing necessity of hobbies and this would seem to indicate their intention of building these into their lives as an insurance against boredom and mental stagnation.

These 520 winners are great travelers and hop about this country and abroad on vacations, business, for schooling, and in military assignments. Since Washington is a crossroads we frequently see them for short visits and they bring news of others they have seen in far off places and in strange coincident meetings. Search winners consider themselves introduced in advance and hence can find other winner associates in almost any geographical location.

To the question, "Has the Search hindered your development as a scientist?" The winners voiced a majority "No!" but the small minority who said "yes" gave reasons that were promptly passed along to new winners as a warning. These included a caution against being too confident, mistakenly believing that the winner tag can eliminate the necessity for hard work in order to succeed and a reiteration that there is no command that they must be scientists. The one who complained that the Search gave him a "pedestal complex" was voicing what is certainly felt in greater or less degree by every winner. This early marking for potential success places a heavy responsibility on any 'teen-ager but by far the greater number accept it as a challenge and a goal to live up to the trust placed in them.

To the question, "How has the Search helped you?" the answers fell into the following order in number of responses:

1. Personal stimulation in increased self confidence. A responsibility to succeed.
2. Financial assistance. Increased "bargaining power."
3. Meeting new people.
4. Career guidance. Raising the level of ambitions.

No better program is known to us for increasing the number of students who will eventually be scientists than to follow the pattern thus verified by these young people:

1. Find those with aptitude early.
2. Confirm their desire by helping them to prove to themselves they can do it.
3. Show them what the life is like by letting them know scientists.
4. Help them financially if they need it.

Fourteen years ago we began an experiment to test the possibility of recognizing science research potential at high school senior age. Conclusive evidence is now at hand to prove this can be done.

But the roots of science inclination develop long before high school senior age. We are now attempting to demonstrate it is wasteful to wait until high school graduation to spot our coming scientists. This experiment, called the National Science Fair, now in its sixth year, shows great promise of achieving this extended goal.

A DISSECTIBLE MODEL OF SIMPLE COLUMNAR EPITHELIUM FOR TEACHING HISTOLOGY

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One of the more difficult concepts for the beginning student in histology to grasp is that cells possess a third dimension. On the first day of his laboratory study he is confronted with prepared slides on which are mounted sectioned tissues having obvious length and breadth but no appreciable thickness, and throughout the remainder of the course the instructor must struggle constantly against the tendency of the average student to forget that cells have thick-

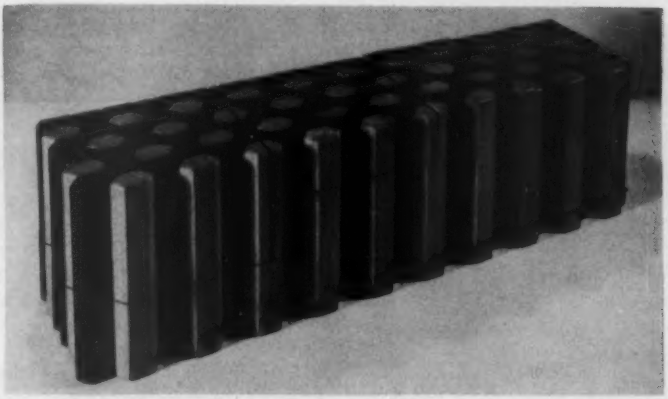

FIG. 1. *A view of two sides of the model with uncut cells to illustrate the fact that cells possess thickness as well as length and breadth.*

ness. Even more difficult for the student to achieve is the understanding that great variations in the microscopic appearances result from but slight variations in the level or direction of the microtome blade as it passes through the tissue.

In connection with a kodachrome motion picture entitled "Histological Technique,"[1] a model was constructed to illustrate the effects of plane and level of section upon the appearance of simple columnar epithelium. The model measures 22 x 6 x 6 inches and consists of 126 cells formed out of hexagonal blocks of three kinds of wood having contrasting colors (walnut, birch and mahogany).

In order to emphasize the three dimensional concept, the cells on one side and one end were left uncut (Fig. 1). The other side and the end illustrate the appearance of the epithelium when sectioned vertically and show nuclei with nucleoli and chromatin granules (Fig. 2). Two transverse sections through the model show the appearance when the plane of section passes through the nuclei (Fig.

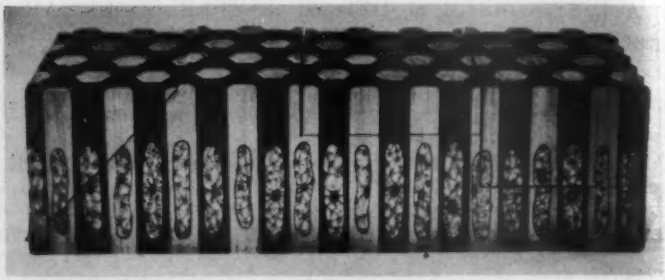

FIG. 2. *This face of the model shows the appearance of cells in which the plane of section is vertical to the epithelium. Within the nuclei may be seen nucleoli and chromatin granules.*

3A) and when it passes above the level of the nuclei (Fig. 3B). The latter has proved very effective in explaining to the student how large areas of digestive tract epithelium of certain slides appear to be completely devoid of nuclei.

The most instructive aspect of this model is the obliquely sectioned end. When this hinged section is opened (Fig. 3C and Fig. 4) the cut surfaces appear to show a stratified cuboidal epithelium. Its true nature is suggested by several characteristics of an obliquely cut simple epithelium:

1. The upper layers appear to be composed of cells without nuclei.
2. The nuclei of the next layer or layers appear to be round and occupy only a very small fraction of the volume of the cell.

FIG. 3. *In this view the model has been dissected to illustrate the effects of different planes of section upon the appearance of the cells. At A the plane of section passes through the middle of the nuclei. In some cells the plane of section passes through the nucleoli; in others it does not. At B the plane of section lies higher in the cells. This makes them appear to be completely devoid of nuclei. C is an oblique section illustrating what would appear to be a stratified cuboidal epithelium under the microscope. This is better shown in Fig. 4.*

3. The next layer or two have large, oval appearing nuclei, many of which lack a nucleolus.
4. As the plane of section reaches the proximal tips of the nuclei it appears to cut through cells with very small nuclei or completely devoid of nuclei.

Summary: This report is a description of a dissectible model which has proved effective in teaching the effects of plane of section upon the histological appearance of a simple columnar epithelium.

1. Miller, J. A., Jr. 1952 Histological Technique—A kodachrome moving picture. Anat. Rec., 112; 171.

FIG. 4. *The obliquely sectioned surface appears to consist of a stratified cuboidal epithelium six cells in thickness. The upper two layers show no nuclei. In the third layer are seen the very small distal tips of three nuclei. The next two layers show large nuclei in all of the cells. Again in the lowest layer most of the cells appear to lack nuclei.*

ADDENDUM:—The italicised phrase in lines 25 and 26 page 109 of the September 1954 number should have read, "he first placed the rivers before the mountains." instead of "the mountains before the rivers."

AN INVESTMENT IN THE FUTURE*

ROBERT LAGEMANN
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We all know about the shortage of scientific manpower. All of us know that our technology is outrunning the educational system of our country, for so great has been the advancement of scientific knowledge during the last few decades and so rapidly are we opening new areas of research that our schools cannot keep up with the demand for trained scientific personnel. It is obvious that more physicists are needed in this atomic age, and so it goes, from aerodynamicist through zoologist.

The need for scientists in industry, government and the military, as well as in teaching, is critical. Every sign indicates that it will become still more critical in the years ahead. Everyone is aware of this, and I will not take the time to point out in detail where the shortages are most acute. Instead, I wish to suggest one of several possible remedial measures, one which will take time to develop, but one nonetheless sure.

Whatever may be the reasons for the shortage, the focal point of the problem, it seems to me, is in the nation's secondary schools, the schools where the nation's youth make the decisions that determine the composition of our working force. Here a very large percentage decide what vocation to take up. Shall they go to a liberal arts college? Shall they go to an engineering school? Shall they find a high paying job, possibly with little personal satisfaction attached, or one with relatively small economic return but one they enjoy nonetheless? Of course the colleges must have a hand in solving our need for scientists, but the secondary schools reach so many more potential candidates for scientific careers.

Let's take a look at the situation in the almost 30,000 public and private secondary schools in the United States. Their enrollment has been increasing faster than the population. We are now faced with an even greater rise in enrollment due to the soaring post-war birth rate and because of a slowly increasing percent of students who go to high school.

What about the teachers needed to care for this increase? Writing in the *Scientific American*, Feb., 1954, Fletcher Watson estimates that whereas we now have some 340,000 high school teachers, we will need 418,000 by 1960 and 520,000 by 1966. In the case of science teachers the required number will rise from the 67,000 barely adequate for today's needs to 84,000 by 1960 and 100,000 by 1966. Right now, says Watson, some 7,000 new science teachers are needed each year. Yet the supply of new science teachers is dropping. Instead of the 7,000 science teachers needed, only 5,000 graduated from our colleges last year and many of those qualified to teach went into industry or to the military instead.

*Read at the Regional Science Fair Work Conference, University of Georgia, Athens, November 5, 1954.

For want of a few thousand competent new science teachers each year, science instruction in our schools must either be dropped (as is often the case), or be curtailed, or becomes a farce boring and repellent to promising students. And when that happens, the number of students choosing careers in science likewise will decrease.

It is becoming increasingly clear that the shortage of scientists in our region and our country can be solved most efficaciously by encouraging and training young people to become science teachers. How such encouragement can be provided with some hope of success, I intend to point out in a moment, omitting the obviously desirable, but immediately unworkable, suggestion that we raise the salaries of teachers.

First, however, I would like to comment on our own region as a source of scientists. It is well known that the production of scientists in the South is singularly low. Except for the production of mathematicians, the South has not sent its proportionate share of young people into science. What hypothesis can we set up in explanation?

Until the Civil War, the South possessed many of the characteristics of a feudal order: there was a large number of imported slaves, a class of impoverished whites, and as the influential social group, the relatively wealthy land-owners whose politics were conservative and whose social customs were of a gentility prized even today. In this society there arose at intervals certain individuals who, more than their fellows, exhibited scientific interests of broad scope entitling them to be called natural philosophers. But there never developed in the South discoverers of scientific truth nor inventors. In the main, on the contrary, these natural philosophers were interpreters and transmitters of the knowledge of the past. While considerable science was taught in the colleges of the South, science, like the humanities, which were in part soon to be supplanted by the social sciences, was not available to a large proportion of the population, and caste and gentility were dominating forces in the social order. For many years the schools clung to a classical curriculum. Innovation was slow and lagged behind the rest of the country. The science taught was looked upon as deductive rather than inductive; logic and mathematics were more important aspects of science than experimentation.

Under these condition the southerner would not be expected to embrace science, and the various studies on the origins of scientists support this view. For example, more physicists come from Utah, Oregon, Washington and the other western states (in relation to their populations) than from any other geographical section. If the southerner was hampered by tradition, the westerner was receptive to the new ideas constantly a product of science; if the southerner held in high regard social and aesthetic values, the frontiersman was pragmatic and close to nature. Thus we can attribute the failure of the South to produce scientists largely to its cultural traditions. Too, the South did not possess the mental attitude of the frontier, so similar to that of the working scientists. And then, in the South orthodoxy of religious belief prevailed longer than in the East or Midwest,

with the consequence that the conflict between science and religion affected adversely the number wishing to study science. Instead of embarking on a scientific career, the southerner turned to politics, to the military, and to writing where he is disproportionately represented among eminent men.

Current developments in the South, particularly the movement of industry to this area, not only will create a further demand for scientists but will foster their development, for it is a postulate of the history of science that the growth of science is closely correlated to the development of the practical arts.

I wish now to turn to consideration of one of the most important factors known to influence young people to enter science as a career. I refer to the teachers of science. Since they play such an important role in the stimulation of interest in scientific careers, including reproduction of their own kind, it is of interest to note just what are the characteristics of a distinguished teacher, where by distinguished we mean those who send the most pupils on in science, as teachers or active workers in the field.

Knapp and Goodrich, in their book, "The Origins of American Scientists," have examined this question. They first sought out those teachers who have over a number of years sent extraordinary numbers of their students on to careers in science. Then they went to these former students and asked them what they thought were the distinguishing characteristics of their former teachers. (Although they studied college science teachers, I think their results have validity for high school teachers also).

Table 1 gives a list of certain characteristics of teachers and the correlation of their success in training future scientists with the ratings on these characteristics as made by their former pupils. Correlations less than 0.32 for biologists and less than 0.26 for chemists are without significance. Space does not permit any elaboration of the meaning of the terms used for characterization except in the case of "entrepreneur activity" by which is meant the degree

TABLE I

CORRELATIONS OF TEACHER RATINGS WITH TEACHER SUCCESS

Factor	Biologists (39)	Chemists (57)
1. Breadth	.43	.38
2. Administrative participation	.35	.32
3. Conscientiousness	.20	.22
4. Lectures	.27	.49
5. Demonstrations	.03	−.01
6. Laboratory	.26	.33
7. Professional eminence	.53	.58
8. Command presence	.42	.53
9. Entrepreneur activity	.69	.68
10. Energy	.54	.67
11. Demandingness	.60	.71
12. Warmth	.55	.51
13. Verbal skill	.47	.37
14. Pedagogic zest	.67	.54
15. Assertiveness	.30	.39

to which the teacher shows enterprise in obtaining scholarships for his students to continue their education, participates in professional organizations, and obtains special grants for furthering his department.

In summarizing their conclusions, Knapp and Goodrich say that the superior biology teacher "is characterized by an energy-and-demandingness component, a human-warmth component, and an intellectual component related to professional competence. The factor of least significance is the professional eminence component."

"Successful chemistry teachers," they comment, "are not characterized by distinctive scholarship, whereas, they are singularly distinguished by vital energy, enterprise, and entrepreneur ability." It should be added that these conclusions do not mean that a teacher must not know his subject. He should, but beyond a certain point further competence cannot replace desirable personality characteristics.

Furthermore, Knapp and Goodrich, in the language of psychology, picture a successful science teacher as a "father figure of a rather forceful and appealing type. In this role he serves as (1) an object of admiration and emulation; (2) a source of coercion; and (3) an understanding confidant." One might interpret this as indicating that we should have more men science teachers, if we want boys and girls to take up science careers. I think we should. But more importtant I think that the conclusion having significance at this conference is that the science teacher can arrange a student-teacher relationship wherein the important characteristics of a good teacher are brought into play. It seems to me that an ideal situation for exploiting the human-warmth characteristic, the energy-and-demandingness component, the factors of social accessibility and enterprise, is the science fair. At a Science Fair, and particularly during the preparations for a Fair, the teacher and pupil meet in a friendly, cooperative atmosphere; they become better acquainted; the social accessibility of the teacher is more easily realized. At a Fair cold, impersonal relations can be broken down and the teacher may succeed as he or she never has before.

I do not say that the Fair is not a teaching device—that it cannot serve to teach facts and principles as well as develop certain desirable attitudes and interests on the part of the student. It does all of that. What I would like to emphasize is that the Science Fair is a key activity in finding and encouraging youngsters to take up careers in science, including careers in the teaching of science.

Perhaps I should stop at this appropriate point. But I do wish to stress one more point. In what I have said, I have assumed that it is desirable to teach science and to encourage young people to take careers in science. I do not believe there should be a moratorium on science, a time for the humanists and social scientists to catch up, so to speak. I believe we need science as a source of power in a dynamic civilization.

It is worthy of note in the history of mankind that the three periods in which the most surprising intellectual developments are found,

namely the Age of the Greeks, the Renaissance, and our own times, are all of them periods of expansion, geographically and economically. In Greece, a way of life producing some of the most remarkable intellectual accomplishments of man was at the same time based on commerce in the Mediterranean and on exchange of goods with other lands. The Renaissance, with its increased opportunity for leisure and the revival of learning, was founded on the wealth of the Indies. In the 19th century our dynamic, growing society was based on our western frontier and the wealth provided by the Industrial Revolution. When our frontiers disappear, where shall we turn for new outlets for our population, for new incentives, for new innovations? Many historians feel that there are no more frontiers and predict we can look forward only to decadence and deterioration.

To those who hold to this pessimistic view, I would suggest that science, as it unfolds and as it consciously is motivated by the highest of ideals, can provide frontiers yet undreamed of and can provide the knowledge necessary to invigorate our society. To achieve this stimulating effect on civilization we need continued science; we need some of the best minds of our day; and to get them, I commend, as one simple device, the Science Fair.

I have worked with two fairs in two states and I am of the belief that as a result the colleges are already getting more and better science students than they would have otherwise. I believe more and more potential scientists are going to get their first real motivation toward a career through such fairs. But whether they go on in science or not, the students participating in fairs are the better for it and so are you for having helped them.

OCCURRENCE, POSSIBLE ORIGIN AND GEOLOGICAL SIGNIFICANCE OF THE PHOSPHATIC CONCRETIONS IN THE MAURY SHALE

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Emory University

Introduction

Phosphatic concretions are common in the Maury shale, which is of questionable Mississippian age. Field and laboratory studies were made of the concretions, the enclosing rock, and of similar concretions in the underlying Chattanooga black shale.

The concretions are interpreted to be syngenetic in origin; forming in relatively shallow water, and imply geological and chemical environments that are duplicated in present day seas.

Concretions are nodular growths of various minerals sparsely distributed through the country rock. They vary greatly in size, shape, composition, distribution, and method of growth. They seem to result when embedding rock prevents the orderly arrangement of molecules or by the action of colloidal attraction. They may occur with a

nucleus of one or more grains of detrital material, fossil fragments, or without any definite nucleus.

The concretions here described are found to be accretions, or "true-concretions," formed by outward growth from a central nucleus.

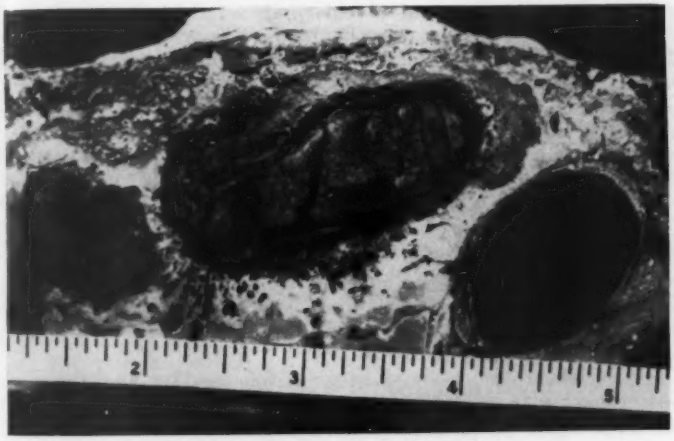

FIG. 1. *Variation in size of nodules.*

LOCATION AND DESCRIPTION

The Maury shale overlies the Chattanooga black shale, which crops out in a general N.E.-S.W. strike belt in the N.W. corner of Georgia; it consists of green, glauconitic clayey to sandy shale 8 inches to 3 ft.

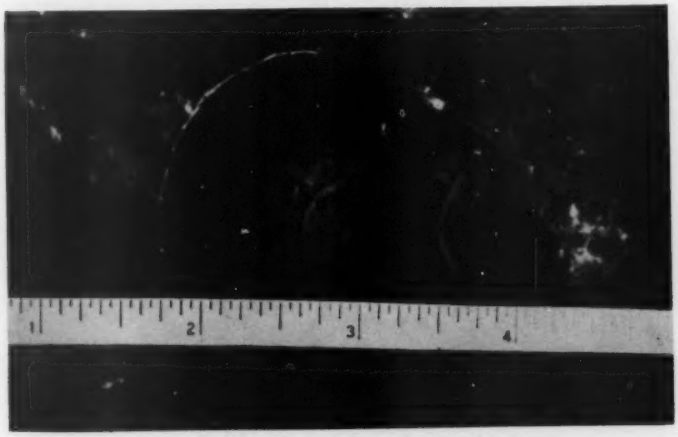

FIG. 2. *Nodule surrounding fossil fragment.*

in thickness, the concretions being concentrated along the sandy zones.

Concretions vary in size from approximately .5 to 3 inches in diameter and possess spherical, oblong, or discoidal shapes. They are disseminated throughout the formation. Concretions were also observed in the upper part of the black shale, and nodular structures in the Fort Payne chert overlying the Maury were found to be fossils replaced by chert rather than concretions.

Concretions were studied at Gore, Menlo, LaFayette, Cooper Heights, and Taylor Ridge, all Georgia localities. Contact between the Maury and the underlying Chattanooga black shale is believed to be conformable in all of the outcrops studied, no indicative evidence of an unconformity being found.

OCCURRENCE OF THE CONCRETIONS

The Maury was found to consist of two general types of layers: one consists of greenish-gray, fine clay-shale; the other is green, sandy clay-shale. In the fine, greenish-gray layer, no laminae are observed, but in the green, sandy layer crenulated laminae curve around the concretions.

No relationship is observed between the jointing and the concretions occurring in the black shale. No jointing was observed in the layer of the Maury along which the concretions were concentrated.

MICROSCOPIC AND CHEMICAL ANALYSIS

Chemical tests for calcium carbonate and phosphate were positive. Insoluble residue of the concretions is 37% and consists of quartz, organic matter, black carbonaceous residue, glauconite, and pyrite.

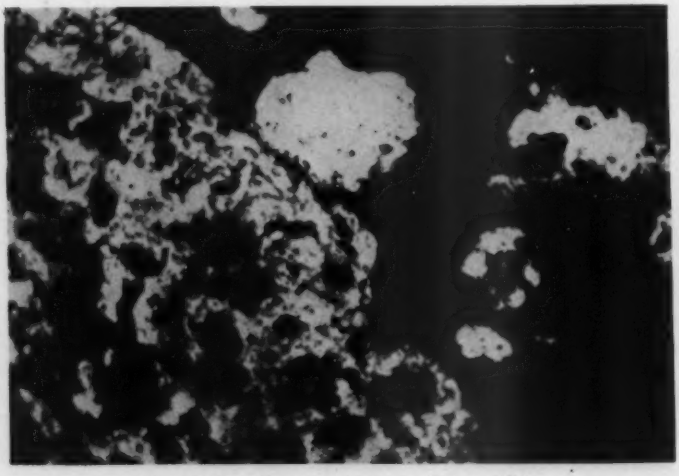

FIG. 3. *Pellet like particles in thin sections.*

Positive identification could not be made of microscopic ovules of greenish-white material, which may possibly be fecal pellets as described by Takahashi and Tsugio (1929) which are found on the shallow sea floor off the coast of Japan.

Thin sections show the concretions to consist of concentric, light and dark layers with quartz microlites and granules concentrated in the lighter layers. The darker layers consist predominantly of dark carbonaceous material, and dark brown collophane. Pseudo-oolites and spherulites of silicia are disseminated throughout the sections with pellet-like forms containing glauconite near the periphery. In some sections collophane is altered to dahlite, which occurs in stringers or as incrustations. The majority of the concretions contain no definite nucleus but some show fossils as nuclei. Collophane occurs in massive form and with colloform structure; observed pyrite is amorphous.

The green clay-shale was found to contain glauconite disseminated in round pellets, broken, flaky fragments elongated, parallel to the laminae, and in granules. Laminae consist of alternate concentrations of silica and glauconitic material with some concentration of microscopic granules of collophane between the layers.

ORIGIN OF THE CONCRETIONS

The concretions are interpreted as syngenetic in origin involving contemporaneous formation with enclosing material. It is questionable if solutions could circulate freely through material as impervious as clay-shale. If the concretions are epigenetic, there should be some evidence of the original stratification planes in relation to the concretions; the curving of the laminae around the concretions is be-

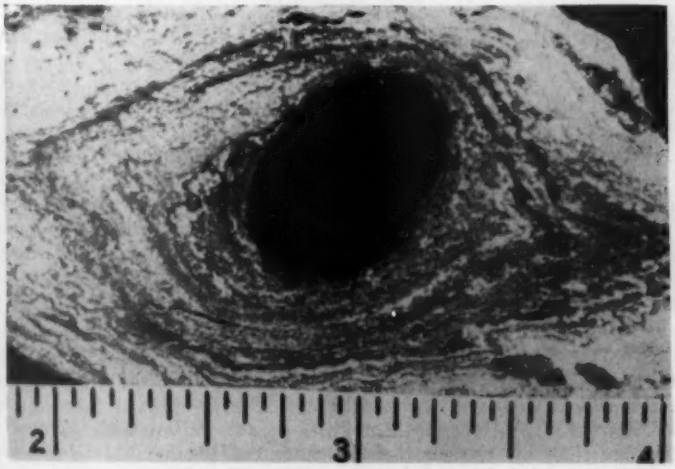

FIG. 4. *Banding around nodule.*

lieved to result from deposition of material around the concretions as they were formed and the crenulations due to later compaction and shrinkage of the clay-shale around the concretions.

CHEMICAL AND BIOLOGICAL FACTORS OF DEPOSITION

Pyrite is believed to result from the action of hydrogen sulfide and iron carbonate, the hydrogen sulfide being evolved from decaying organic matter due to action by anaerobic bacteria, the phosphate being derived by precipitation of phosphate already present in the sea water and also by solution and precipitation from phosphatic shells. It has been shown by Takahashi and Tsugio (1929) that glauconite can be formed by direct chemical action and Galliher (1935) found that it can also be formed by subaqueous alteration of biotite. The presence of biotite in the insoluble residue and the variety of forms in which glauconite occurs indicate formation by the latter method.

The force conceived to bring together the molecules in formation of the concretions is a form of molecular attraction resulting from the colloidal nature of the solutions. An observed difference in the color and nature of the country rock in the vicinity of the concretions has been pointed to by Todd (1903) as an indication of the impoverishing of the country rock by the withdrawal of molecules involved in the formation of the concretions from it.

ENVIRONMENTAL CONDITIONS

The concretions are believed to represent deposition in the shallower, shoreward facies of the Chattanooga shale environment with a change from essentially undisturbed, anaerobic conditions during the deposition of the black shale to conditions intermediate between anaerobic and aerobic with some bottom agitation and relatively slower rate of sedimentation. This is indicated by a decrease in organic content in the Maury; increase in coarser detrital material, lack of uniformity of deposition, presence of glauconite, and decrease in pyrite content. Hadding (1940) has postulated the following conclusions concerning the formation of glauconite: "It is always marine, always sublittoral, always a shallow sea formation, as a rule formed in agitated water, as a rule formed under decreased deposition of detritus, often formed under negative sedimentation and never formed in highly oxygenous water." It is believed that the decrease in pyrite is due to agitation of the flow and the accompanying decrease in the amount of organic matter thereby reducing the amount of hydrogen sulfide available for precipitation.

DUPLICATION IN PRESENT DAY SEAS

Dietz, Emery and Shepard (1938); Galliher (1935); Shepard and MacDonald (1938) and Takahashi and Tsugio (1929) have found the following: (1) Phosphatic nodules in association with glauconite on the sea floor off the coast of Southern California; (2) Glauconite, phosphate, and pyrite were found to be related in the deposits of

Monterey Bay, California; (3) Sediments of Santa Monica Bay, California, were found to be similar to the deposits of Monterey Bay; (4) Glauconite, pyrite globules, and phosphatic pellets are found in association in littoral deposits off the coast of Japan.

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DEPOSITIONAL FEATURES OF AN ORDOVICIAN LAMINATED LIMESTONE IN NORTHWEST GEORGIA

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The second laminated limestone is one of three laminated limestones that occur in the Ordovician section of northwest Georgia. This zone is typically composed of thin, fine-grained, bluish-gray calcareous laminae alternating with yellow argillaceous laminae, and for this reason has been named the "Tiger-stripe" limestone by Vest (1952). To determine the characteristics of the alternating laminae is the purpose of this investigation; therefore, the stratigraphic relations will not be discussed. Excellent stratigraphic descriptions are given in Masters theses by Vest (1952), Wright (1952), and Ingram (1954).

METHOD OF INVESTIGATION

Samples were collected from outcrops described in the previously mentioned theses. Fifteen outcrops were visited and thirty samples, from regular intervals through the section were collected. Polished sections and sections etched with dilute hydrochloric acid proved to be the most useful for study of the laminae. Thin sections and insoluble residues aided in determining the mineral composition and the grain size of the component materials.

DESCRIPTION OF LAMINAE

The laminae are alternating yellow argillaceous laminae and bluish-gray calcareous laminae. The laminae are generally less than 5 mm. in thickness, but some layers are as much as 6 inches thick. In one polished section (figure 2) 37 laminae were counted in 5 cm. In a thin section of this sample the argillaceous laminae average 0.37 mm., and the calcareous laminae average 0.52 mm. The calcareous laminae are generally thicker than the argillaceous laminae throughout the zone. Vest (1952) points out that the argillaceous laminae initiate each pair, and grade upward into the calcareous laminae. This is generally the case; however, there are instances where this relationship is obscure.

Etched sections reveal a concentration of very fine quartz grains along the contact between the argillaceous and calcareous laminae. These quartz grains are believed to have settled through the limey muds, their passage being stopped by the more compact argillaceous material.

Although generally continuous, the laminae are, in some cases, interrupttd or disturbed by true conglomerates and breccias, intraformational conglomerates and breccias, and by crumpling. A true breccia consisting of green silty pebbles which interrupt the laminae, is found in the lower part of the zone near Haysville (figure 2). Figure 3 shows an intraformational conglomerate from the west side of Pigeon Mountain along the Lookout Mountain Scenic Highway. The specimen, from the upper half of the zone, shows an argillaceous layer that has been broken and rounded to form granules averaging 2 mm. in diameter.

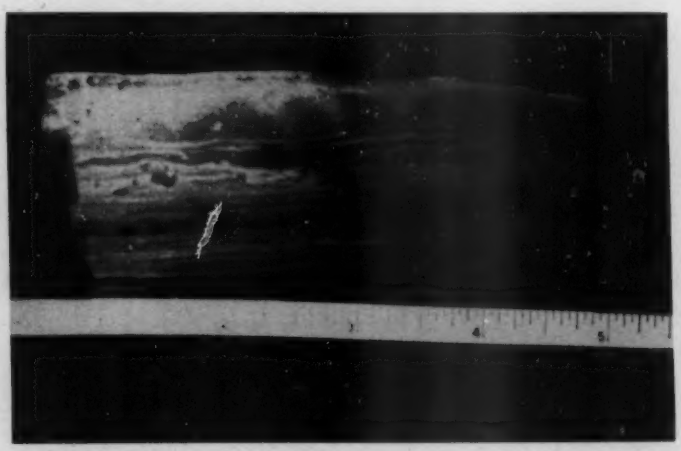

FIG. 1. *Alternating argillaceous and calcareous laminate, 2 miles south of Trenton, Georgia, in a cut along the Southern Railroad. Surface polished and etched.*

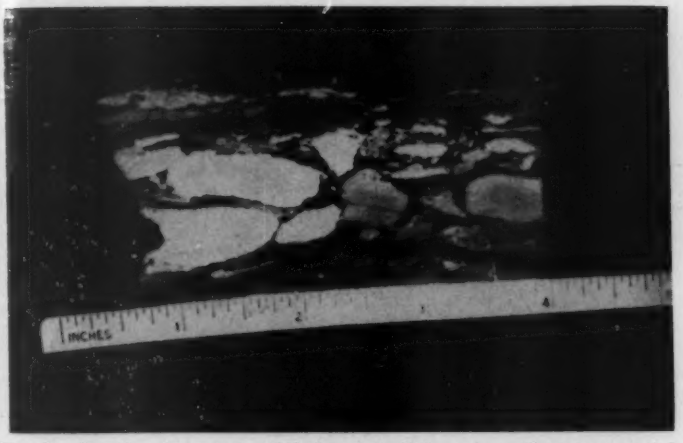

FIG. 2. *Angular fragments of indurated silstone in a limestone matrix from the lower part of the zone near Haysville. Surface polished and etched.*

Another interesting feature associated with the laminae are cavities filled with argillaceous material, shell debris, detrital and crystalline calcite. These cavities are of two types: (1) those that are obicular in shape and that disturb the laminae, similar to the ones found in figure 1, and (2) those that penetrate the laminae as if bored by an organism of some type. The latter cavities are circular in cross

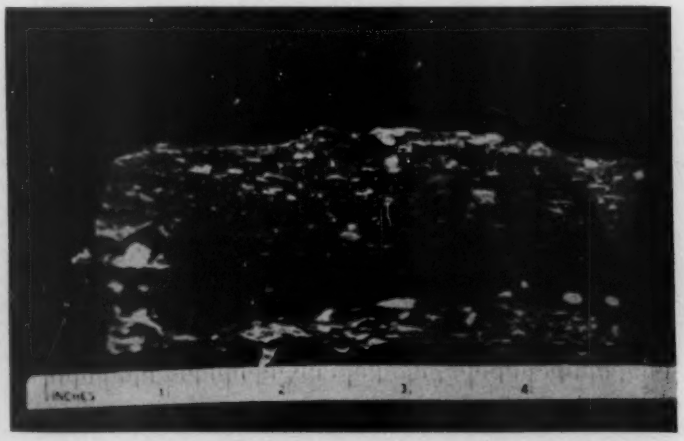

FIG. 3. *Intraformational conglomerate of silt fragments in limestone from the upper half of the zone on the west side of Pigeon Mtn. along Lookout Mtn. Scenic Highway. Surface polished and etched.*

section; hence, they are not believed to be mud cracks. The lower parts of the cavities are filled with detrital material ;the upper parts with calcite. This arrangement of material represents geopetal fabrics, which are aids in determining the top and the bottom of a rock unit.

MINERALOGY

The mineralogy of the zone as observed in thin sections and in insoluble residues is relatively simple, which may be due to the fineness of the component materials. Detrital calcite, detrital quartz, silt and smaller sized particles, and a minor amount of muscovite are the major constituents of the zone. Ostracod carapaces, the only fossils in the zone, are an additional source of calcite. The average grain size material is 0.5 mm., with the exception of the crystalline calcite which ranges up to 2 mm. or larger.

The insoluble residues indicate a general increase in silt content toward the top of the zone. In the lower part of the zone the insoluble content ranges from 1.9 to 19 percent and averages 13.5 percent; in the upper part of the zone the insoluble content ranges from 23.8 to 51.3 percent and averages 25.8 percent.

Conclusions

From the evidence at hand the following conclusions can be drawn:

1. Rubey (1930), who described the fine-grained, laminated cretaceous sediments of Wyoming, noted that laminae are developed by alternations in a series of continuous deposition, and by a variation in the rate of supply or of deposition of the component materials. In the case of the second laminated limestone, the graduation of the argillaceous material into the calcareous material and the sharp contact between the latter and the succeeding argillaceous layer appear to indicate, as in the cretaceous sediments of Wyoming, a series of continuous deposition with a variation in the rate of supply of material. The argillaceous material was probably brought into the depositional environment during periods of terrestrial storms and floods. The calcareous material was then deposited when the argillaceous content of the depositional environment was sufficiently low to permit the precipitation of calcium carbonate. Hence, a climatic cycle could account for the alternating argillaceous and calcareous laminae.

2. The condition of preservation of the laminae and their associated intraformational conglomerates and breccias offer two possibilities as to the depositional environment. The two possibilities are: (1) The materials were deposited below wave base, with an occasional storm wave reaching the bottom, disturbing the laminae and forming the intraformational conglomerates and breccias; (2) the laminae were formed in shallow water in a protected lagoon. Exposure to subaerial conditions produced the intraformational conglomerates and breccias.

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